

Autonomic response to valsalva maneuver in patients of cervical spondylosis**Mohita Singh^{*1}, Indu Khurana² and Z.S. Kundu³**¹Demonstrator, Department of Physiology, PGIMS, Rohtak-124001, India²Senior Professor, Department of Physiology, PGIMS, Rohtak-124001, India³Professor, Department of Orthopaedics, PGIMS, Rohtak-124001, India***Correspondence Info:**

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Abstract

Background: Cervical spondylosis(CS) is a broad term which describes the age related chronic disc degeneration which starts in the intervertebral disc with osteophyte formation and lead to physiological degenerative cascade that contributes to biomechanical changes that result in neural and vascular compression. Autonomic balance in the body can be influenced from this compression.

Aim and objectives: The aim of this study was to assess the autonomic balance in response to stress in patients of cervical spondylosis.

Material and methods: Heart rate variability (HRV) was recorded during valsalva maneuver (VM) and recovery period, in two groups comprising of thirty patients with CS and thirty healthy age and sex matched controls. The results were analysed in time and frequency domains by using student t-test (significance level at $p < 0.05$).

Observations and

Results: There was an inefficient autonomic response during the period of stress, with increased sympathetic tone during the recovery period.

Discussion: HRV is as a simple, non-invasive measure of the autonomic activity which analyses beat to beat variation in the heart rate and VM further improves the sensitivity of its interpretation.

Conclusion: CS patients have an altered autonomic response to stress and a higher sympathetic tone than controls.

Keywords: cervical spondylosis, heart rate variability, valsalva maneuver

1. Introduction

Cervical spondylosis is a broad term which describes the age related chronic disc degeneration. Etiological factors are usually multifactorial, including poor posture, anxiety, depression, neck strain and sporting or occupational activities. Aging is the major risk factor that contributes to the onset of cervical spondylosis.[1,2] The degenerative changes start in the intervertebral disc with osteophyte formation leading to physiological degenerative cascade that contributes to biomechanical changes that result in neural and vascular compression.[3,4] The activity and relative balance between sympathetic and parasympathetic nervous system is regulated by afferent inputs directed primarily to brain. Dysfunction of the ANS may result from diseases that affect either central nervous system (CNS) or peripheral autonomic nervous system. [5,6] The tests for assessment of Autonomic nervous system (ANS) are based on evaluation of the cardiovascular reflexes triggered by performing specific provocative maneuvers. The analysis of heart rate variability (HRV) has

been used to investigate sympathovagal imbalance within cardiovascular system. Changes in heart rate during orthostatic testing and valsalva maneuver reflect the parasympathetic modulation. It is one of the most informative study methods employed to evaluate the integrity of cardiac autonomic function based on heart rate responses associated with the arterial pressure stabilizing baroreflex mechanism.[7]

1.1 Aims and objectives

To assess the level of autonomic activity in patients of CS by studying the effect of valsalva maneuver on heart rate variability (HRV).

2. Material and methods

This prospective random case control study was conducted in the Department of Physiology in collaboration with Department of Orthopaedics, Pt. B. D. Sharma PGIMS, Rohtak in patients with cervical spondylosis and normal healthy subjects. The study sample comprised of group I

consisting of thirty randomly selected age and sex matched healthy controls and group II of thirty patients diagnosed with cervical spondylosis (age group 30-60 years of either sex). Written informed consent was taken from all the participants included in both the study groups. This study was approved by the institutional ethical committee. The whole procedure was explained in detail to each subject in his/her own language to allay any fear or apprehension. Consent was taken from every individual to undergo whole procedure. The tests were conducted during working hours (9am-1pm) to avoid diurnal variation. All the subjects were tested under similar laboratory conditions and allowed to acclimatize themselves to the experimental and environmental conditions.

2.1 Inclusion criteria

The patients with history of symptoms of cervical spondylosis for at least 6 months, restriction of neck movements, impaired dermatomal sensations and reflexes (triceps, biceps and supinator jerks), radiating pain and radiologically diagnosed cases of CS (Plain X-ray-AP and Lateral view) were included in the study.

2.2 Exclusion criteria

The patients with acute onset of symptoms likely due to prolapsed intervertebral disc, history of smoking, any chronic drug intake in recent past which may alter the autonomic functions, history of any neck surgery and/or cervical spine injury, any infection, inflammation or malignancy or co-morbid systemic disease like diabetes and hypertension were excluded from the study.

2.3 Autonomic activity

Autonomic activity in the two study groups was assessed by means of HRV, analyzed in time and frequency domains in the Department of Physiology. POWERLAB 26T POLYRITE D system with appropriate recommendations was used for recording. The subject was asked to lie down comfortably. Then 3 disposable pre-gelled electrodes were attached to left arm, right arm and left leg for ECG recording. The basal recording of ECG (lead II) was taken for 5 minutes and assessed by time and frequency domain methods.

2.4 Valsalva maneuver

Aneroid sphygmomanometer connected with a mouthpiece through a tube was used. The length of the pressure tubing was appropriate (35-40cms) to keep an eye on the meter reading while blowing through it. The subjects were trained properly before performing the test. They were instructed to blow into mouthpiece so that pressure of about 40 mm Hg was maintained for 15 seconds. Care was taken that the glottis remained closed and the subject was not merely blowing with his /her cheeks. Then the subject was asked to release the pressure. HRV were recorded during and after the procedure.

2.3 Statistical analysis

Statistical analysis was done by student t-test using SPSS software version 20. Significance of result was predicted on the basis of p value (significance level < 0.05).

3. Observation and results

Heart Rate Variability during Valsalva maneuver (15s)

3.1 Time domain analysis

Table 1: Time domain variables of HRV in group I and group II during Valsalva maneuver

Parameter	Group I (Mean ± SD)	Group II (Mean ± SD)	p value
SDNN (ms)	46.55 ± 29.56	54.83 ± 33.99	*0.032
RMSSD	26.02 ± 2.03	27.34 ± 15.76	0.758
NN 50	2.03 ± 2.92	2.15 ± 2.01	0.856

*Statistical significance (p<0.05)

There was a significant increase in SDNN (54.83 ± 33.99, p< 0.05) in group II as compared to group I. RMSSD and NN50 were comparable in both the groups.

3.2 Frequency domain analysis

Table 2: Frequency domain variables of HRV in group I and group II during Valsalva maneuver

Parameter	Group I (Mean ± SD)	Group II (Mean ± SD)	p value
VLF(ms ²)	60161 ± 1178.88	657.70 ± 665.67	0.824
LF(nu)	76.93 ± 44.98	74.27 ± 22.55	0.776
LF(ms ²)	996.61 ± 1128.15	1865 ± 265.51	*0.047
HF(nu)	21.26 ± 16.66	18.92 ± 15.67	0.588
HF(ms ²)	225.54 ± 272.32	220.68 ± 317.76	0.951
LF/HF ratio	8.03 ± 10.91	7.84 ± 6.96	0.939

**Statistical significance (p<0.05)

The observations showed a decrease in LF(nu), HF(nu), HF(ms²) and LF/HF ratio in group II as compared to group I. However there was significant increase in [LF (ms²) 1865 ± 265.51, p <0.05]

Heart rate variability during recovery period (5 min) of Valsalva maneuver

3.3 Time domain analysis

Table 3: Time domain variables of HRV in group I and group II during Valsalva recovery

Parameter	Group I (Mean ± SD)	Group II (Mean ± SD)	p value
SDNN (ms)	43.38 ± 22.84	31.40 ± 11.34	*0.022
RMSSD	29.6 ± 19.22	21.89 ± 13.18	*0.042
NN 50	27.35 ± 41.17	16.07 ± 25.57	0.256

*Statistical significance (p<0.05)

Group II showed a significant decrease in SDNN (31.40 ± 11.34, p< 0.05) and RMSSD (21.89 ± 13.18, p< 0.05) as compared to group I. No significant difference was observed in NN50.

3.4 Frequency domain analysis

Table 4: Frequency domain variables of HRV in group I and group II during Valsalva recovery

Parameter	Group I (mean ± SD)	Group II (mean ± SD)	p value
VLF(ms ²)	1118.06 ± 1305.42	476.10 ± 386.28	*0.031
LF(nu)	49.42 ± 15.24	57.44 ± 14.92	*0.030
LF(ms ²)	541.82 ± 970.93	248.40 ± 227.32	*0.041
HF(nu)	35.98 ± 15.20	33.21 ± 12.86	0.487
HF(ms ²)	280.10 ± 455.43	198.06 ± 258.24	0.444
LF/HF ratio	1.68 ± 0.88	3.88 ± 9.15	*0.026

*Statistical significance (p<0.05)

The above table showed a significant increase in [LF(nu), 57.44± 14.92, p< 0.05] and LF/HF ratio,(3.88±9.15,

$p < 0.05$) and a significant decrease in $[LF(ms^2), 248.40 \pm 227.32, p < 0.05]$ in group II as compared to group I. HF (nu) and HF(ms^2) showed an insignificant decrease in group II.

4. Discussion

Autonomic nervous system (ANS) plays an important role in the regulation of the physiological processes of the human organism during normal and pathological conditions. It is responsible for regulation and integration of internal organs functioning. Together with the endocrine and immunological systems it determines the status of the internal environment of the organism and adjusts it to its current needs, enabling adaptation of the internal environment to changes in the external environment. Disorders of autonomic regulation are described in multiple and diverse diseases, both those that directly afflict the nervous system as well as those afflicting other organs, where they trigger or enhance pathological symptoms.[8]

A study conducted at Autonomic unit of Department of clinical neurology, London attributed symptoms like neck pain in suboccipital and paracervical region to a possible autonomic derangement, along with symptoms of visual disturbance, dizziness and fainting episodes.[9]

Eric Toussiro *et al* studied abnormal autonomic cardiovascular control in ankylosing spondylitis demonstrated a change in autonomic functions as evidenced by a decreased parasympathetic activity and higher heart rate. [10]

Valsalva maneuver (VM) is an important noninvasive autonomic function test that evaluates function of baroreceptors. During valsalva maneuver, there is an abrupt voluntary elevation of intrathoracic and intraabdominal pressure caused due to blowing against a pneumatic resistance maintaining a predetermined pressure. Changes occurring in blood pressure reflect not only the mechanical effects on the heart and blood vessels but also ongoing reflex changes in autonomic activity. [11] The Valsalva-Weber maneuver is a procedure executed in many functional situations in everyday life associated with expiratory straining, usually performed against a closed glottis. It is one of the most informative study methods employed to evaluate the integrity of cardiac autonomic function based on heart rate responses associated with the arterial pressure stabilizing baroreflex mechanism.

Heart rate responses to the Valsalva-Weber maneuver are the result of reflex mechanisms, predominantly of baroreceptor origin, which involve principally the parasympathetic autonomic nervous system but also the sympathetic division. Cardiopulmonary and chemoreceptor reflexes appear to be also involved to a lesser extent, interacting with the baroreflex. [12-15]

The quantification of heart rate or heart interval variations associated with the Valsalva-Weber maneuver has been used as a sensitive, reliable, reproducible, and very simple method for characterizing the suddenly acting cardiac

autonomic modulation. This approach has helped to characterize particularly the parasympathetic nervous function in healthy subjects and patients with different clinical conditions.[16]

Heart rate variability is generally assessed based on time-domain or frequency-domain analysis. Although the frequency-domain analysis of HRV is much better understood, it is also mostly used for research purposes. Time-domain HRV analysis has the widest application in routine clinical evaluation and some of its indices have become well-documented, independent risk factors of cardiovascular events.[12]

SDNN and RMSSD are qualitative markers of vagal activity. Unlike SDNN which measures both short term as well as long term effects, RMSSD measures just the short term effects. Kleiger *et al* had documented that RMSSD and NN50 are correlated with SDNN and are marker of parasympathetic activity.[17] The high frequency (HF) band of HRV power spectrum estimates the cardiac vagal control and the low frequency (LF) band reflects both sympathetic and parasympathetic tone. [18] The LF/HF ratio reflects the absolute and relative changes between the sympathetic and parasympathetic components of the ANS, by characterizing the sympathovagal balance on heart.[19]

R Xavier *et al* studied the effect of valsalva maneuver on short term HRV recording and found that there is an increased sympathetic activity during the strain (higher LF band) and an increased parasympathetic response after the strain period (higher HF band).[20] Fernando L *et al* revealed in their study that when performed carefully and evaluated correctly, the Valsalva maneuver is a helpful tool in the assessment of cardiovascular autonomic function.[16]

In the present study it was observed that the cases of CS showed a blunted response during the strain period (decreased LF and LF/HF ratio) and persistence of higher sympathetic tone (increased LF and LF/HF ratio) during the recovery period. This concludes that there is a delayed response to stress as well as delay in the recovery reflecting a definitive autonomic imbalance in these patients.

Thayer JF and *et al* reviewed the evidence of vagal function as a cardiovascular risk factor and concluded that decreased vagal function precedes the development of a number of risk factors, both modifiable and non – modifiable.[21] Verrier *et al* in a paper by the Heart Rate Working Group comprised of European and U.S. investigators stated that heart rate is a pivotal variable that is precisely regulated in health but disrupted in disease. An enhanced adrenergic activity is arrhythmogenic and efferent vagal tone is cardio protective by opposing its action. Elevated heart rate catalyzes the atherosclerotic processes and are associated with arterial stiffness and turbulent flow in cerebral and coronary circulations.[22]

The presence or absence of respiratory sinus arrhythmia constitutes an important measure of

cardiovascular health. This neural control is closely linked to heart rate (HR) and baroreceptor reflex activity. From the afferent informations, by means of a complex interaction between stimulation and inhibition, the responses from sympathetic and parasympathetic pathways are formulated and modify the HR, by adapting to the needs of each moment.[23] It is unclear whether respiratory sinus arrhythmia is causally related to improved cardiac health or is a marker of beneficial autonomic influences.[24] Changes in patterns of HRV provides a sensitive and early indicator of health impairments. High HRV is a sign of good adaptation, by characterizing a healthy individual with efficient autonomic mechanisms. Conversely, low HRV is often an indicator of abnormal and inadequate adaptation of the ANS, which may indicate the presence of physiological malfunction in the patient, requiring further investigations in order to find a specific diagnosis.

5. Limitations of the study

Assessment of autonomic status is difficult and time consuming. It requires precision and experience. Patients may consider some of the tests unpleasant (e.g. cold pressor test, valsalva maneuver) and they may be reluctant to participate in a second test run. Major methodological limitations of HRV are related to reliability criteria depending on factors like sample size, duration of recording, filtering techniques and interpretation of results.

6. Conclusion

The findings of our study suggest that in patients with CS there was a blunted response during the period of stress while the sympathetic overdrive persisted in the recovery period leading to deranged autonomic control. These patients show a relatively higher sympathetic tone as compared to control group, may be due to the disease process. There is a possibility of exacerbation of their symptomatology and predisposition to hypertension and cardiovascular risk due to sympathetic over-activity.

Increased vagal tone is cardioprotective as there is decreased sensitivity of beta receptors. Thus, an increased parasympathetic modulation induces electrical stability while a high sympathetic activity increases the vulnerability of the heart and cardiovascular events. Moreover, these subtle autonomic disruptions occur much before the appearance of symptoms of the disease itself and can be helpful as an adjunct to diagnostic tests, prognostic follow-up and drug prescriptions. Autonomic function testing can therefore prove to be a valuable tool in aiding the clinicians to timely diagnose and stratify the cervical spondylosis patients according to cardiovascular risks, if any and give timely adjunctive management, thereby preventing significant morbidity.[25,26]

Current available literature has provided enough evidence that HRV provides indirect indices of autonomic

modulation which are sensitive and reproducible. It is the most sensitive noninvasive and reliable tool available to assess the autonomic modulations in a number of disease conditions and patients can be benefitted by including this test in routine clinical assessment for early detection and to prevent the risk of cardiovascular morbidity. Conventional tests like valsalva maneuver may serve as useful adjunct to further improve the sensitivity of its interpretation.

References

- [1] Kelly JC, Groarke PJ, Butler JS, Poynton AR, O'Byrne JM. The natural history and clinical syndromes of degenerative cervical spondylosis. *Adv Ortho* 2012; 2012: 393642.
- [2] Binder AN. Cervical spondylosis and neck pain. *BMJ* 2007; 334(7592): 527-31.
- [3] Ferrara LA. The biomechanics of cervical spondylosis. *Adv Ortho* 2012; 2012: 493605.
- [4] Engstrom JW. Back and neck pain. In: Fauci AS, Braunwald E, Kasper DL, Hauser SL, Longo DL, Jameson JL, Loscalzo J, editors. *Harrison's Principles of Internal Medicine*. 17thed. New Delhi: McGraw Hill; 2008. p.116.
- [5] Shields RW Jr. Functional anatomy of the autonomic nervous system. *J Clin Neurol* 1993; 10(1): 2-13.
- [6] Navarro X. Physiology of autonomic nervous system. *Rev Neurol.*, 2002; 35(6): 553-62.
- [7] Zygmunt A and Stanczyk J. Methods of evaluation of autonomic nervous system. *Arch Med Sci* 2010; 6(1):11-8.
- [8] Jaradeh SS, Prieto TE. Evaluation of the autonomic nervous system. *Phys Med Rehabil Clin N Am* 2003; 14: 287-305.
- [9] Bleadsale-Barr KM, Mathias CJ. Neck and other muscle pains in autonomic failure: their association with orthostatic hypotension. *JR Soc Med* 1998; 91: 355-9.
- [10] Toussiro E, Bouhaddi MB, Poncet JC, Cappelle S, Henriot MT, Wendling D *et al*. Abnormal autonomic cardiovascular control in ankylosing spondylitis. *Ann Rheum Dis* 1999; 58: 481-7.
- [11] Singer W, Opfer-Gehrking TL, McPhee BR, Hilz MJ, Low PA. Influence of posture on valsalva maneuver. *Clin Sci* 2001; 100: 433-40.
- [12] Bennet T, Farquhar IK, Hosking DJ, Hampton JR. Assessment of methods for estimating autonomic nervous control of the heart in patients with diabetes mellitus. *Diabetes* 1978; 27: 1167-78.
- [13] Eckberg DL. Parasympathetic cardiovascular control in human disease: a critical review of methods and results. *Am J Physiol Heart Circ Physiol* 1980; 239: H581-93.
- [14] Shepherd JT, Mancina G. Reflex control of the human cardiovascular system. *Rev Physiol Pharmacol* 1986; 105:1-99.

- [15] Effect of beta adrenergic blockade on beat to beat response to valsalva maneuver. *Br Heart J* 1974; 36:1082-6.
- [16] Fernando L, Junqueira LF. Teaching cardiac autonomic function dynamics employing the Valsalva (Valsalva-Weber) maneuver. *Adv Physiol Educ* 2008; 32:100-6.
- [17] Kleiger RE, Miller JP, Bigger JTL, Moss AJ. Decreased heart rate variability and its association with increased mortality after acute myocardial infarction. *Am J Cardio* 1987; 59: 256-62.
- [18] Heart rate variability: Standards of measurement, physiological interpretation and clinical use. Task force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. *Circulation* 1996; 93:1043-65.
- [19] Ellenberg MR, Honet JC, Treanor WJ. Cervical radiculopathy. *Arch Phys Med Rehabil* 1994; 75 (3): 342-52.
- [20] Xavier R, Laranjo S, Ducla-Soares E, Andrade A, Boto JP, Santos-Bento M, Ducla-Soares JL, Carvalho LS, Rocha I. The Valsalva maneuver revisited by wavelets. *Rev Port Cardiol* 2008; 27(4): 435-41.
- [21] Thayer JF, Lane RD. The role of vagal function in the risk for cardiovascular disease and mortality. *Biol Psychol* 2007; 74(2): 224-42.
- [22] Verrier LR. Heart rate, autonomic markers and cardiac mortality. *Heart rhythm* 2009; 6(11): S68-75.
- [23] Hrushesky WJM, Fader D, Schimitt O, Gilbersten V. The respiratory sinus arrhythmia: A measure of cardiac age. *Science* 1984; 224: 1001-4.
- [24] Opie LH. Heart physiology: From cell to circulation. 4th Philadelphia: Lippincott Williams and Wilkins; 2004.p.142.
- [25] Scott WA. Assessment of the autonomic nervous system; In: Moss and Adams heart disease in infants and adolescents including the fetus and young adult; Baltimore. Williams and Wilkins; 1995.p.172-81.
- [26] Mathias CJ. Autonomic diseases: clinical features and laboratory evaluation. *J Neurol Neurosurg Psychiatry* 2003; 74(3): 31-41.